

AIR FORCE FELLOWS

AIR UNIVERSITY

DEPARTMENT OF DEFENSE AND ENERGY INDEPENDENCE:  
OPTIMISM MEETS REALITY

by

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## *Preface*

This report addresses a topic that is important now and will become increasingly so as the nation grapples with the problem of how to continue a way of life that is powered by a finite commodity. In the past, energy crises have arisen but were then “laid aside” as additional oil reserves became available and prices dropped. But now the problem of dwindling supplies and rising prices is joined by the dilemma of global climate change. The two factors together create an argument more compelling than it was even a decade ago for reducing the nation’s use of fossil fuel. The Department of Defense has sagely stepped up to share responsibility in the nation’s quest for alternative energy sources. DOD—particularly the Air Force—has made tremendous progress in adopting alternative energy sources, however, one can sense that if the department does not soon commit to a long-term corporate energy strategy, we must accept that momentum created over the past year will decline as attentions shift and priorities change. This report discusses the current realities associated with DOD and the Air Force’s search for alternative fuel and “energy independence.”

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### *Abstract*

The Department of Defense (DOD) is at the center of the nation's discussion about national energy security. DOD, the largest single consumer of fuel in the United States, recognizes that it plays a central role in national efforts to reduce the use of and reliance on fossil fuel. Aviation fuel makes up the largest portion of fossil fuel consumed by DOD and therefore represents the area of greatest potential savings. This report examines DOD's use of aviation fuel, presents options available to reduce that use, discusses relevant issues, and concludes with an analysis of the challenges DOD and the Air Force faces in becoming less reliant on fossil fuel.

Reducing DOD's consumption of aviation fuel could by itself significantly reduce the department's overall reliance on fossil fuel. In Fiscal Year 2005, DOD consumed roughly 125 million barrels of oil—approximately 1.2% of the nation's total. About 74% of that was used to power mobility vehicles—Air Force aircraft, Navy ships, and Army ground vehicles. Over half—roughly 52%—was aviation fuel.<sup>1</sup>

There are several ways in which DOD can reduce its use of fossil-based aviation fuel. Each has advantages and disadvantages and no single option provides the perfect solution. Advanced technologies, such as synthetic fuels, offer potential alternatives but further development and study are required before DOD can employ them on a large scale. DOD can also take measures to decrease its use of fuel. Possible options include upgrading aircraft engines and modifying operational procedures. Many of these measures, however, are costly and must compete for funding with other operational priorities.

DOD has expended significant resources in the past year to address its reliance on fossil fuels but risks jeopardizing its progress due to the lack of centralized leadership and a comprehensive corporate strategy. Increasingly, law-makers and the public appear also to be looking to DOD to supply national leadership in its search for alternative fuels—particularly in the area of synthetic aviation fuel—but DOD seems reluctant to take on that role. While DOD and other federal agencies dialogue about which is best positioned to lead the nation to energy independence, the success of DOD’s own long-term energy goals depends on its designating a single focal point with the authority and resources to implement a department-wide energy strategy and to organize, prioritize, and coordinate the myriad of competing energy-related projects and interests.

## **Notes**

<sup>1</sup> Aviation fuel is also used in “non-aircraft” systems such as tanks and generators in order to reduce logistics requirements on the battlefield. By comparison, about 32% of the nation’s energy is used as auto gas, auto diesel, and jet fuel combined (Energy Information Agency 2005 (Department of Energy) consumption data quoted in *Energy Security Task Force Overview of Findings*.

## **Chapter 1**

### **Introduction**

DOD, the largest single consumer of energy and aviation fuel in the nation, recognizes the need to reduce its reliance on fossil fuel. The success of the United States military aviation strategy has long been dependent on fossil fuels. Without question, the United States Air Force dominates the world in numbers and sophistication of aircraft however, a tremendous amount of fuel is required to get them to where the wars are. Fossil fuels have always been—and still are—the most efficient source of energy to do that. With their high power density and relative low cost, fossil fuels will be difficult to replace. But the need to replace them is becoming more compelling every day. The three most compelling reasons are:

1. Make the nation's security independent of foreign oil
2. Reduce the military reliance on fossil fuel, a finite resource
3. Contribute to national well-being by reducing a major source of greenhouse gas emissions.

Reducing energy use is not a new practice for DOD. For a number of years, the department has been making steady progress in decreasing its energy use on its installations and in its facilities.<sup>1</sup> Following the sharp rise in oil prices after Hurricane Katrina in August 2005, DOD began to also systematically address the need to decrease the amount of energy used in tactical weapon systems.<sup>2</sup> Furthermore, Congress included language in the 2007 Defense Authorizations

and Appropriations Acts directing the department to reduce its use of fossil fuels by increasing the fuel efficiency of its weapons platforms and by exploring the potential use of synthetic fuel.

Many alternative fuel options exist for DOD to explore; they all have advantages and disadvantages. Some provide a way to reduce reliance on foreign oil but not on fossil fuel. Others provide a way to decrease reliance on fossil fuel (while decreasing greenhouse gas emissions) but do not possess enough energy density to power an aircraft. Yet other options do not provide alternative energy sources but involve modifying weapons systems so that they use less of it. Examples of possible options include making synthetic fuel from coal, making synthetic fuel from biomass (organic matter), and adding winglets to aircraft wings for improved fuel efficiency.

### Notes

<sup>1</sup> DOD, like other federal agencies, has had to comply with a series of mandates to decrease energy through efficiencies in facilities and increase the use of renewable forms of energy. Most recently, President George W. Bush signed the Energy Policy Act of 2005 and issued Executive Order 13423 in 2007, both of which update (and generally make more stringent) existing energy conservation measures for installations and non-tactical vehicles.

<sup>2</sup> Prior to August 2005, there had been some sporadic attention given the topic of reducing fuel use in operational systems, but relatively little action was taken in the area. See U.S. Department of Defense, *More Capable Warfighting Through Reduced Fuel Burden: The Defense Science Board Task Force on Improving Fuel Efficiency of Weapons and Platforms*. (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, January 2001).

## **Chapter 2**

### **Aviation Fuel Use**

DOD's pattern of fuel use is unique. Although it could be argued that DOD is a small portion of the nation's energy market overall (1.2%), most of that energy (74%) goes to powering its mobility vehicles—Air Force aircraft, Navy ships, and Army ground vehicles. Aviation fuel alone accounts for approximately 52% of the energy DOD buys each year.<sup>1</sup> By comparison, aviation accounts for only 4% of energy use in the United States.<sup>2</sup>

Fuel costs, although less than 3% of the total DOD budget, have a significant impact on the department's operating costs.<sup>3</sup> In Fiscal Year 2005, DOD spent just under \$11 billion on energy, with about \$6.3 billion of that on aviation fuel.<sup>4</sup> Consequently, fluctuations in the price of oil can have a significant impact. For every \$10 increase in a barrel of oil, DOD's operating costs increase by approximately \$1.3 billion.<sup>5</sup> The Air Force, which purchases most of DOD's aviation fuel, bears the largest share of those costs. That same \$10 increase in a barrel of oil increases the Air Force's already sizable annual fuel costs<sup>6</sup> by \$600 million.

As the owner and operator of most of DOD's fixed-wing aircraft, the Air Force not only buys but uses the largest share of the department's aviation fuel. Fuel use varies significantly between aircraft. For example, the B-52H, one of the oldest aircraft in the service's inventory, has a maximum takeoff weight of 488,000 pounds, runs on eight TF-33 turbine engines, and burns approximately 3500 gallons per flight hour. That is 138 pounds of aircraft for each gallon

per hour. By contrast, the C-5B, designed with 1980s technology, is a larger aircraft with four engines, has a maximum takeoff weight of 769,000 pounds, and also burns about 3500 gallons per flight hour. That is 219 pounds of aircraft for each gallon per hour—an increase of 59% over the B-52 capabilities. The T-38, a high-performance jet-engine aircraft used for training, has a maximum takeoff weight of 12,000 and burns only about 395 gallons per flight hour.<sup>7</sup> That is only 30 pounds of aircraft for each gallon per hour—much less than either of the above. The lower fuel efficiency of the T-38 compared to either the B-52H or the C-5B is a reflection of the smaller aircraft's aerodynamic design, afterburning engines, and much shorter sortie length rather than the efficiency of its engines. Fuel consumption rates for a representative selection of Air Force aircraft is provided in **Table 1**.

**Table 1. Aircraft Fuel Consumption**

(in gallons per flight hour)

Aircraft	2004	2005	2006
A-10	605	615	603
B-1B	3891	3965	3874
B-2A	2155	2175	2181
B-52H	3386	3521	3524
C-130E	746	725	742
C-135C/E	2552	1835	1700
C-17A	2897	2926	2781
C-21A	223	219	181
C-5A/B	3572	3541	3384
C-5B	3638	3701	3503
E-3B/C	2219	2206	2105
F-15A/B	1641	1737	1715

F-15C/D	1676	1698	1715
F-15E	1935	1978	1879
F-22A	2173	2025	Not Available
T-38A/C	413	413	395

**Source:** Headquarters United States Air Force, AF/A3O.

Delivering fuel to its end user can add significantly to its cost. The price of fuel with the costs of delivery added in is referred to as the “fully burdened” cost of fuel. For example, the cost of a gallon of fuel put into an aircraft sitting on a flight line is a fairly straight-forward computation and ranges between about \$2 and \$3 per gallon. Refueling an aircraft in flight, however, combines the cost of the gallon of fuel with the cost of an aerial refueling tanker flight, which includes the cost of a crew, maintenance on the aircraft, and the fuel to fly it. The estimated cost of a fully burdened gallon of fuel delivered via tanker is estimated to be about \$20.<sup>8/9</sup>

Some have proposed that a lack of specificity on the fully burdened cost of fuel hinders DOD’s ability to account for the actual affect of fuel on its budget. In their 2001 report, the Defense Science Board (DSB) suggested that the standard fuel price used by the Defense Energy Supply Center (DESC)<sup>10</sup> does not accurately reflect the true cost of fuel across the services. The DSB contended that the standard price does not take into account the cost of delivering the fuel from the DESC supply point to the end user. The task force asserted that not knowing the fully burdened cost of fuel, “prevents an end-to-end view of fuel utilization in decision making, does not reflect the DOD’s true fuel costs, masks energy efficiency benefits, and distorts platform design choices.”<sup>11</sup>

## Notes

<sup>1</sup> Joint Statement [of] Honorable John J. Young, Jr., Director, Defense, Research and Engineering [and] Mr. Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), Before the *Subcommittees on Terrorism, Unconventional Threats and Capabilities and Readiness of the House Armed Services Committee*, 109 Cong., 2d sess., 2006, 4-6.

<sup>2</sup> JASON, *Reducing DOD Fossil-Fuel Dependence*, The MITRE Corporation (McClean, VA, September 2006.), iv.

<sup>3</sup> Based on a Fiscal Year 2006 Defense Regular Appropriation of \$399.4 billion.

<sup>4</sup> U.S. Department of Defense, *FY2005 Energy Management Report*, (Washington, DC: U.S. Department of Defense, 2006), Table 1-4.

<sup>5</sup> Joint Statement, Young and Grone, 5.

<sup>6</sup> The Air Force spends about \$5 billion a year on fuel. Bryan Bender, “Pentagon Study Says Oil Reliance Strains Military,” *Boston Globe*, May 1, 2007.

<sup>7</sup> Air Force Cost Analysis Agency, Fuel Data Consumption Comparison, staff study, February 2007.

<sup>8</sup> Masood Farivar, “Military Seeks Oil Savings,” Defense News, Vol. 22, No. 1, 9 January 2007.

<sup>9</sup> The price of fuel delivered to a tank on a battlefield has been estimated to be as much as \$400-\$600 a gallon. See Amory B. Lovins, “Battling Fuel Waste in the Military” (Snowmass, CO: Rocky Mountain Institute, 2001), <http://www.rmi.org/sitelpages/pid939.php> (accessed 10 April 2007).

<sup>10</sup> The Defense Energy Support Center (DESC) purchases all of DOD’s liquid fuel then sells it to their customers: the military services and other defense and government agencies. DESC offers fuel to its customers at a standard price—set in advance of the fiscal year—that allows customers to budget for fuel without having to factor in the risks associated with normal variations in the commercial fuel market.

<sup>11</sup> DSB Report, 1.

## **Chapter 3**

### **Government Studies**

DOD has conducted or sponsored a number of studies in recent years to examine DOD's fuel use, determine the extent to which that use is problematic, and recommend actions.<sup>1</sup> Two general conclusions seem to emerge from various government studies. The first is that there does not appear to be one ideal alternative fuel with which to replace or augment the fossil fuel already although different technologies are being pursued to varying degrees. The second is that there appears to be several methods currently available to DOD with which it can decrease fuel consumption.

The earliest comprehensive DOD study on fuel use, conducted by the Defense Science Board in 2001, focused on the fuel efficiency of weapon systems and was the first to suggest that the true cost of fuel—the fully burdened rate—was not sufficiently understood by decision-makers. Two other comprehensive studies were completed more recently, in September 2006. The JASON report, Reducing DOD Fossil Fuel Dependence, asserted that an energy shortage was unlikely in the near term to hinder DOD operations and emphasized the value of optimizing the energy efficiency of weapon systems over pursuing alternative fuels at this time. The Defense Task Force on Energy Security was an internal cross-functional group that looked at energy use throughout the department. It presented three recommendations: 1) increase the energy

efficiency of weapon systems, 2) accelerate energy-saving initiatives for facilities, and 3) establish an alternative fuels programs.

## **2001 Defense Science Board Task Force**

In 2000, the Under Secretary of Defense for Acquisition, Technology, and Logistics directed the Defense Science Board to form a task force to examine how DOD could improve the efficiency of their weapons systems. The task force also identified institutional barriers that impeded the department's understanding of and ability to capture the full advantages of more efficient systems. The task force was not asked to look at possible sources of alternative fuel and they did not address that topic in their report. They reported five significant findings:

**Finding #1: Although significant warfighting, logistics and cost benefits occur when weapons systems are made more fuel-efficient, these benefits are not valued or emphasized in the DOD requirements and acquisition processes.**

When buying new weapons, DOD placed performance as its highest priority and seemed to overlook how fuel efficiency could result in improved performance. Furthermore, when developing new systems it did not seem to take into account the effects the system could have on the total force (e.g. how a system's logistics requirements may affect the vulnerability of the logistics delivery chain.)

**Finding #2: The DOD currently prices fuel based on the wholesale refinery price and does not include the cost of delivery to its customers. This prevents an end-to-end view of fuel utilization in decision-making, does not reflect the DOD's true fuel costs, masks energy efficiency benefits, and distorts platform design choices.**

According to the DSB, overlooking the true cost of fuel masked the benefits of fuel efficiency. As a consequence, fuel efficiency is not regarded as a relevant factor in the

acquisition of weapon systems or in other logistics related decisions. For example, in 1997, using an average fuel price of \$0.97, the Air Force estimated that re-engining the B-52H would generate a savings of just under \$400 million over 40 years. Based on that calculation, the service concluded that retrofitting was not cost-effective. The DSB reworked the equation using an average fuel cost of \$1.50 per gallon (the board estimated that 10% of the fuel would be delivered via aerial refueling at a cost of \$17.50 per gallon) and calculated a savings of \$1.7 billion.<sup>2</sup>

**Finding #3: The DOD resource allocation and accounting processes (PPBS, DOD Comptroller) do not reward fuel efficiency or penalize inefficiency.**

The task force found that DOD interest in fuel efficiency had been mainly limited to meeting goals established by legislation or executive order. Since those applied to installations (including non-tactical vehicles) and facilities, there was little incentive to improve the fuel efficiency of weapon systems. Additionally, the department had no way to quantify—and therefore place value on—the benefits of making weapon systems more fuel efficient.

**Finding #4: Operational and logistics wargaming of fuel requirements is not cross-linked to the Service requirements development or acquisition program processes.**

The task force found that in DOD combat simulation exercises, services emphasized mission execution while adequate fuel supplies were considered a constant. DSB asserted that doing so left DOD unaware of the potential effects of fuel efficiency on combat operations and of the vulnerability of the fuel supply chain. Furthermore, with no model of efficient or inefficient fuel use, DOD could not analyze fuel related logistical requirements as part of the acquisition process

**Finding #5: High payoff, fuel-efficient technologies are available now to improve warfighting effectiveness in current weapon systems through retrofit and in new systems acquisition.**

The task force found that there were existing technologies that could increase weapon systems' fuel efficiency. However, without the tools to analyze the collective benefits of fuel efficiency to warfighting capability, the value of the improvements could be mischaracterized and perhaps not fully appreciated.

## JASON

JASON, an independent scientific advisory group for DOD, published its report, *Reducing DOD Fossil-Fuel Dependence*, in September 2006. JASON was asked by the Director, Defense Research and Engineering (DDR&E) to assess ways in which DOD could reduce its demand for fossil fuel by the application of advanced technology including alternative energy sources. The group was asked specifically not to conduct a detailed analysis on U.S. Air Force fuel use.

The JASON report contained five findings:

**Finding #1: Absent any major world-wide “upheavals,” no fossil fuel shortages are expected to affect DOD for the next 25 years.**

JASON stated in their report that DOD's fuel needs could be met, at current use rates, without imports from the Middle East. Although 63% of oil consumed in United States is imported, the 1.9% consumed by DOD could be supplied by the annual production of two Gulf of Mexico oil platforms.<sup>3</sup> Furthermore, JASON noted that Middle East oil imports account for only 18% of the nation's total imports and that by decreasing fossil fuel consumption by 12%, the United States could “wean” itself from Middle East imports if the need arose.<sup>4</sup>

**Finding #2: DOD fuel costs, though high, represent only about 2.5-3% of the DOD budget and should not be a “primary decision driver” at present.**

JASON determined that other fuel related issues such as life-cycle costs of weapon systems and the supply chain (in terms of both money and human life) were more significant and compelling factors but that the cost of fuel may become a significant issue in the future.

**Finding #3: Although revolutionary options in weapon system design exist in their early stages, the technologies that currently promise the most significant fuel savings are light-weighting and modernizing diesel engines.**

JASON saw little use at the present for most alternative ground vehicle designs such as hybrids, all-electric, or fuel-cell vehicles. In the case of the first two, military use patterns would not allow optimal use of the technologies. In the case of fuel-cells, JASON found that the technology was not sufficiently mature and that there was not a good way to transport hydrogen fuel to theater. JASON suggested light-weighting vehicle by decreasing the weight of manned vehicles and using more unmanned vehicles.

JASON recommended upgrading the turbine-powered Army M-1 Abrams to a modern diesel and installing fuel consumption tracking devices in vehicles in order to gauge use patterns and collect data with which to make informed decisions on engine selections and optimal efficiency.

**Finding #4: The Department of Defense uses less than 2% of the oil consumed in the United States and is therefore not a large enough consumer to drive the market for conventional or alternative fuels.**

JASON and others have suggested that finding an alternative for fossil fuel must be a national endeavor. According to DOD, it uses approximately 340,000 barrels of oil a day

whereas the daily consumption rate for the United States is roughly 21 million barrels.<sup>5</sup> DOD seems to agree that it plays a significant role in testing, certification, and demonstrating the use of synthetic aviation fuel, but is not a large enough consumer to drive the market.

When considering alternative fuel sources, JASON contended that using “stranded”<sup>6</sup> natural gas to produce liquid fuel with the Fischer-Tropsch process<sup>7</sup> was the most economical and environmentally “friendly” option. They further reported that ethanol was not suitable as a DOD fuel due to its low energy density and high flammability.

**Finding #5: At the present time, fuel produced from crude oil is a better economic value than fuel produced from biomass.**

JASON noted that corn-based ethanol “yields no significant net energy benefit” when its entire production process, which includes the use of energy derived from coal, is taken into account. Furthermore, producing corn or other crops for biofuel competes with food production and exacts a heavy environmental toll.

### **DOD Energy Security Task Force**

In spring 2006, former Secretary of Defense, Donald Rumsfeld, formed a DOD task force with a four-part charter:

1. Examine the issue of energy security
2. Devise a plan for lowering DOD’s fossil fuel requirements
3. Identify alternate energy sources
4. Examine past and ongoing studies to help define DOD’s options. The task force was comprised of representatives from the Office of the Secretary of Defense, Army, Navy, and Air Force, the Joint Staff, the Defense Logistics Agency, and the Defense Advanced Research Projects Agency (DARPA).

The Director of Defense Research and Engineering (DDR&E), who works for the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD (AT&L)), led the effort.

Task force representation included a cross-section of skills within the military departments, the staff of the Chairman of the Joint Chiefs of Staff, and other defense agencies. In September of that year, the task force issued a list of three findings in the form of a slide presentation. There was no accompanying report:

**Finding #1: Increase platform efficiency.**

1. Incorporate delivered cost of fuel into acquisition decisions.
2. Develop more efficient propulsion systems, power generators, and machinery.
3. Develop light-weight vehicles and structures.
4. Strive for operational efficiencies and simulator use (primarily affects the aviation community).

**Finding #2: Accelerate installations' initiatives.**

1. Meet or accelerate energy efficiency goals.
2. Address non-tactical vehicles.
3. Expand Energy Conservation Investment Program/Energy Saving Performance Contracts.

**Finding #3: Establish alternate fuels programs.**

1. Mature and test synthetic/alternative fuels.
2. Measure and assess DOD energy progress.
3. Develop incentives programs for alternate fuel industry.

**Notes**

<sup>1</sup> In addition to the studies discussed herein, other DOD reports on energy and fuel use are:  
Air Force Scientific Advisory Board Quick Look, *Technology options for improved air vehicle fuel efficiency* (2006).

Naval Research Advisory Council, *Study on Future Fuels* (2005).

Army Corps of Engineers, *Energy Trends and Their Implications for U.S. Army Installations* (2005).

Defense Advanced Research Projects Agency, *Petroleum-Free Military Workshop* (2005).

Air Force Studies Board, *Improving the Efficiency of Engines for Large Nonfighter Aircraft* (2007).

<sup>2</sup> DSB Report, 31-33.

<sup>3</sup> JASON Report, 13.

## **Notes**

<sup>4</sup> Ibid., 75.

<sup>5</sup> Department of Defense, *Energy Security Task Force Overview of Findings*, (Washington, D.C.: Department of Defense, 15 March 2007), 4.

<sup>6</sup> “Stranded” natural gas is natural gas that has been discovered but has not been recovered because it was not economically or physically feasible.

<sup>7</sup> The “Fischer-Tropsch” process is a technology that converts coal, natural gas, and other carbon-based materials into a hydrocarbon mixture that can then be made into fuel and other petroleum products. Carbon dioxide and water are by-products of this process.

## **Chapter 4**

### **Options for DOD**

#### **General**

The Department of Defense has several available methods for decreasing its dependence on fossil fuels. They can be placed in two categories: 1) those that increase the supply of alternative fuels and 2) those that decrease the demand for fuel.

In the first category, options include producing synthetic fuel from coal, natural gas, and biomass, as well as hydrogen fuel cells. In the second category, DOD can use various existing technologies to increase the fuel-efficiency of weapon systems and modify operating procedures and policies to use less fuel. All the options have limitations and none provide a perfect solution.

Whether it is more prudent to aggressively pursue alternative fuel or concentrate resources on decreasing the department's demand is a matter of debate. There are many who suggest that DOD can spur the development of a domestic Coal-To-Liquid industry. Others suggest that developing such an industry would unduly contribute to carbon emissions and divert funds from the development of alternative fuels produced from renewable sources as well as from efforts to increase the fuel efficiency of weapon systems. Following is a discussion of the most frequently cited options:

## **Alternative Fuels**

Alternative fuels are often divided into two categories: “synthetic” fuels derived from non-renewable coal and natural gas; and “biofuels,” produced from renewable feedstocks such as corn, sugar cane, and prairie grasses. Both offer advantages and disadvantages as substitutes for fossil fuel.

An issue that may affect DOD’s exploration of alternative fuels is the concept of a “Single Battlespace Fuel.” Ultimately, DOD would like there to be just one in part to decrease risks associated with the elaborate and vulnerable fuel delivery system now in place. However, that may be several years away. Although DOD has been exploring the use of synthetic fuel for aircraft, there is no indication that DOD is actively pursuing alternative fuels for battlefield ground vehicles. There is speculation that this is due to the difficulty of altering the current logistical system and also to the fact that research and development in alternative ground fuel are still in the early stages.<sup>1</sup>

### **Synthetic Fuel**

The technology used to produce synthetic liquid fuel from coal, natural gas, or other solid carbon-containing feedstocks has existed since around 1923 when two German researchers, Franz Fischer and Hans Tropsch, found a way to turn carbon-based materials into useable petroleum products. Their discovery—the “Fischer-Tropsch” process—forms the basis of the technology in use today.<sup>2</sup> Synthetic fuel can also be extracted with chemical processes from oil shale<sup>3</sup> and tar sands (also referred to as oil sands), forms of organic-rich sedimentary rock abundant in North America.<sup>4</sup>

**Pros:** There are many positive things associated with Coal-To-Liquid (CTL) fuel and Gas-To-Liquid (GTL) fuel produced via the Fischer-Tropsch (F-T) process. The most frequently

cited advantage is that it burns cleaner producing fewer carbon emissions. F-T fuels produce approximately 2.4% less carbon dioxide, 50%-90% less particulate matter, and 100% less sulfur than traditional fossil fuels. Other positive attributes of F-T fuels include excellent low temperature properties that improve high altitude operations and low temperature starting; and “superior” thermal stability, which make possible the development of highly fuel efficient engines.<sup>5</sup>

Another oft cited advantage of F-T fuel for DOD is that it can be produced using resources available within the United States. Coal and natural gas, two common feedstocks, are relatively abundant in the United States. The Energy Information Administration estimated in a 1995 report that the United States has an approximately 250 year supply of coal.<sup>6</sup> It should be considered, however, that an increased demand for coal driven by a growing F-T industry may affect that estimate.

The Air Force has already conducted testing of F-T GTL fuel with positive results. In September, 2006, at Edwards Air Force Base in California, the Air Force tested a 50/50 mix of F-T synthetic fuel and Jet Propellant 8 (JP-8)<sup>7</sup> in one engine of a B-52 Stratofortress. No detrimental effects were noted as a result of the flight. In December, 2006, the Air Force tested the synthetic fuel mixture in all eight of the B-52’s engines again with no noticed detrimental effects. The last set of tests—cold weather engine starting—took place in January, 2007, at Minot Air Force Base in North Dakota. Detailed data analysis and further inspections of the aircraft and its engines are ongoing.

**Cons:** The lack of sulfur in F-T fuel, although positive for the environment, presents two problems for aircraft engines. One is that it reduces the fuel’s lubricity, which causes stress on an engine’s moving parts. The other is that less sulfur results in fewer aromatic hydrocarbons,

which, in traditional fossil fuels, have the desirous effect of causing engine seals to swell preventing leakage.

Challenges involved with the large-scale production of F-T fuel may make its long-term use by DOD problematic. Notwithstanding the low carbon emissions produced by burning F-T fuel in engines, total carbon emissions generated through the fuel's production and use are estimated to be twice that produced by the use of conventional petroleum fuel. Although advocates of F-T counter that the carbon emissions generated during fuel manufacture can be sequestered,<sup>8</sup> DOE officials and other experts have stated that large-scale carbon sequestration may be over a decade away.<sup>9</sup>

The Air Force acknowledges that capturing carbon emissions is the “big issue” as they move ahead with the exploration of F-T fuels.<sup>10</sup> According to an Air Force spokesperson, DOD is working with the Department of Energy, the Defense Logistics Agency, and the Task Force on Strategic Unconventional Fuels to explore ways to mitigate the problems that may be associated with F-T fuel production.<sup>11</sup>

Critics of F-T fuel also point to the potential environmental hazards posed by increased coal mining as an additional drawback. Some fear a “mining boom” that could lead to the strip mining of public lands, degraded water quality in some locations, and additional miners put at risk. They question whether a relatively small dent in oil imports is worth what they predict as a 40% increase of coal production. Instead a need for increased fuel efficiency and cleaner energy alternatives is often cited.<sup>12</sup>

Recent efforts at constructing F-T plants in the United States have proven challenging. In September 2006, after supplying DOD 100,000 gallons of synthetic fuel to test in the B-52, Syntroleum closed its demonstration plant in Tulsa, Oklahoma, its revenue having fallen

significantly after completion of its contracts with DOD and the Department of Transportation.<sup>13</sup>

In a February 2007 hearing before the House Energy and Commerce Committee, Secretary of Energy Samuel W. Bodman, in response to questions about why the Department of Energy proposed halting funding for a CTL diesel fuel plant in Pennsylvania, stated that the “financial viability” of the project was questionable.<sup>14</sup> Cost estimates had grown from an original \$612 million in 2003 to approximately \$800 million. On the other hand, potential developers may be encouraged by DOD’s interest in synthetic fuels. In May 2006, when DESC asked companies to submit proposals for the production of 200,000 gallons of F-T fuels for testing by the Air Force and Navy in 2008 and 2009, it received over 20 responses.<sup>15</sup>

Another challenge DOD may face with using F-T fuel is its limited availability. The Air Force has set a goal to use a domestically produced synthetic fuel blend for 50 percent of its aviation fuel by 2016. At current usage rates, that would require approximately 325 million gallons of mixed fuel a year. Based on current trends DOD may have difficulty procuring enough domestically produced synthetic fuel to reach its intended goal.<sup>16</sup> The most robust CTL plant in the world today is SASOL, a company in South Africa that produces about 30% of that country’s fuel—about 150,000 barrels a day.<sup>17</sup>

Establishing a plant in the United States large enough to supply the Air Force with 325 million gallons of a synthetic fuel mix annually may take several years and a significant amount of capital. Estimates for the cost of construction vary between \$1 billion for a plant with a daily output of 10,000 barrels a day<sup>18</sup> to \$5-10 billion for a plant with a daily output of 80,000 barrel a day.<sup>19</sup> According to a 2007 GAO report, DOE estimates that it would cost approximately \$3.5 billion to construct a CTL plant and require 5-6 years.<sup>20</sup>

Compounding the difficulties posed by the high cost of constructing F-T plants are restrictions on DOD's ability to enter into long-term contracts for fuel. Currently the department may only enter into contracts for fuel up to five years—not long enough to provide potential suppliers with the economic assurance necessary to justify construction of a capital intensive plant. The five-year limitation is based on language in 10 U.S. Code 2306b, which outlines the circumstances under which the department may sign a “multiyear contract.” The statute defines a multiyear contract as “a contract for the purchase of property for more than one, but not more than five, program years.”<sup>21</sup>

Proposed legislation (S.154, S.155, and H.R. 370) is intended in part to alleviate the contracting restriction and thus eliminate one of the major barriers to increased F-T synthetic fuel production. The bills—*Coal-To-Liquid Fuel Energy Act of 2007* (S. 154), *Coal-to-Liquid Fuel Act of 2007* (S.155), and *Coal-To-Liquid Fuel Promotion Act of 2007* (H.R. 370)—propose permitting the Department of Defense to enter into contracts for synthetic fuel for up to 25 years. Critics of the legislation express concern that encouraging CTL production before large-scale carbon sequestration is available will increase overall carbon emissions.

## Biofuels

Biofuels are a number of synthetic fuel products that use biological matter as a feedstock: ethanol, produced mainly from corn; cellulosic biofuel, ethanol made from cellulosic plants such as fast-growing trees, prairie grass, and agricultural waste; and biodiesel.<sup>22</sup> Biodiesel, although it is an effective fuel substitute for ground-based vehicles that use diesel, is not an option for aviation.<sup>23</sup>

**Pros:** Many cite as one of the advantages of biofuel that the feedstocks are renewable. Also, unlike synthetic fuel from coal and natural gas, biofuel can theoretically be “carbon

neutral.” That is the carbon dioxide emitted during the burning of biofuel is offset by the carbon dioxide consumed during the feedstocks’ growth. However, current production methods involve the use of some carbon emitting sources, which detracts from the claim of carbon neutrality.

**Cons:** In its present state of technological development, the energy density of biofuel is too low to make it a suitable substitute for jet fuel. Ethanol’s energy density is approximately 25% lower than that of conventional aviation fuel and is therefore not suitable for jets’ turbine engines. Furthermore, ethanol cannot operate at the extreme temperatures military aviation fuel must perform. However, in 2006, the Defense Advanced Research Projects Agency (DARPA) awarded a contract for the development of a synthetic fuel from “oil-rich crops produced by either agriculture or aquaculture (including by not limited to plants, algae, fungi, and bacteria) and which ultimately can be an affordable alternative to petroleum-derived JP-8”<sup>24</sup> Delivery of the product for government testing is expected in 2008.

## **Hydrogen Fuel Cells**

Hydrogen powered fuel cells are a potential alternative power source for DOD and have received considerable attention and study over the past few years.<sup>25</sup> Fuel cells—thin, flat, and stackable—generate electricity through an electrochemical process that combines hydrogen and oxygen and produces water and heat as waste products. One fuel cell generates a modest amount of energy but several can be stacked together for increased power production.

**Pros:** Hydrogen fuel cells have many positive attributes. They are more efficient than combustion engines and do not produce carbon emissions.<sup>26</sup> They do not run down or need to be recharged but can continue operating with the addition of more fuel. For the military, hydrogen fuel cells provide the added benefits of near silent operation and reduced infrared exposure. Furthermore, for portable applications, hydrogen fuel cells weigh less than batteries and retain

power longer. Finally, since hydrogen can be obtained from many sources including water, fuel for the cells could, theoretically, be manufactured on the battlefield.<sup>27</sup>

Fuel cells are already used on several DOD installations mostly in stationary applications such as back-up generators. At Hickam Air Force Base in Hawaii, a hydrogen station produces enough hydrogen everyday to run a 30-foot long, 24-passenger fuel cell shuttle bus with a range of approximately 100 miles.<sup>28</sup>

DOD is also exploring the use of fuel cells for ground vehicles and small portable applications. In September 2006, the Army began testing a fuel cell vehicle manufactured by General Motors, Corp.<sup>29</sup>

**Cons:** A number of obstacles currently prohibit the wide-spread use of hydrogen fuel cells by DOD. Cost, durability, and the transport storage, and delivery of hydrogen fuel are the three largest.

At this stage in their development, fuel cells and hydrogen fuel are costly. According to DOE, a fuel cell with a capacity to generate 80 kilowatts lasts about 1000 hours at a cost of approximately \$110 per kilowatt hour.<sup>30</sup> DOE's goal is to reduce the cost to \$30 per kilowatt hour and extend the fuel cell's life to 5000 hours by 2015.<sup>31</sup> Finally, neither DOD nor the nation has a comprehensive system at this time to transport, store, or deliver hydrogen fuel.

In 2004, DESC issued a report that assessed hydrogen as a potential future fuel for DOD. The report concluded that hydrogen may be a viable source of fuel for small-scale power generation and portable devices within the next 10-30 years however, based on the current state of its development, employing hydrogen fuel cells in weapons systems will not be feasible for 30-40 years.<sup>32</sup> The volume of liquid hydrogen required to power a Navy ship, for example, is four times the volume of conventional fuel. Either carrying capacity on the ship would need to

be expanded four times—especially difficult on ships that are already space-restricted—or the ship would have to refuel four times as often. Also, since hydrogen is highly flammable, there is no practical way to carry it aboard a ship. Similar obstacles preclude its use as an aviation fuel.<sup>33</sup>

### **“Trash to Gas”**

Current research indicates a potential way to convert solid waste at deployed DOD locations into usable energy. Power demands of today’s military base-camps have risen sharply over the past several years.<sup>34</sup> Various technologies exist to turn some of the solid waste generated at the camps into fuel. The technologies vary in efficiency rates and range from incineration—the least efficient conversion method—to pyrolysis, which is the chemical decomposition of organic matter and has an efficiency rate of approximately 70-90%.<sup>35</sup>

**Pros:** Turning a camp’s waste into a source of its energy could benefit DOD in two ways: 1) by decreasing the amount of fuel that must be transported to the camp and 2) by reducing the amount of waste that must be taken out. According to a study conducted by the Army, approximately 79% of waste generated in the field is a potential source of energy.<sup>36</sup> Meals Ready to Eat (MRE) are a prime source for much of it.

**Cons:** One of the challenges of “trash-to-gas” technologies will be making them “user-friendly” for the service members operating them. Furthermore, although theoretically seven pounds of plastic waste equates to about one pound of JP-8, there is not enough plastic waste generated in-theater to make on-site production of aviation fuel feasible.<sup>37</sup> However, DARPA recently awarded a contract to explore a technology for developing a plastic that can be converted into biodiesel in the field.<sup>38</sup>

## **Decreasing Demand**

Increasing fuel efficiency and eliminating areas of waste are the most expedient ways DOD can reduce its reliance on fossil fuel. Just as military facilities abound with energy-saving potential—turning off electrical devices and replacing old heating and cooling systems with more energy efficient models—there are ways in which DOD’s weapon systems and operations can be made more fuel-efficient. The Air Force has modified some operational practices and systems to improve energy efficiency and is considering others.

### **Light-weighting**

Light weight composite materials could greatly increase the fuel efficiency of all DOD platforms. Lighter vehicles can travel faster on less fuel. In one effort to light-weight, DOD is striving for a low-cost titanium alloy to replace heavy steel used in many weapon systems. Titanium is valued for military applications because of its high strength-to-weight ratio and its resistance to corrosion. But at approximately \$30 per pound, titanium alloys are too costly for large-scale military applications and are generally reserved for select aviation and space applications. DOD is sponsoring a program to develop an environmentally friendly production capability for a titanium alloy under \$4 per pound.<sup>39</sup>

### **Increase Landing Weight.**

DOD policy dictates a maximum take-off and landing weight for all aircraft based on their individual structural limitations. The weight for take-off and landing may be the same or an aircraft’s landing weight may be less than that with which it may take off. The KC-135 refueling tanker has one of the most restrictive landing weight requirements in the Air Force fleet. If a KC-135 approaches a landing too heavy, the crew must rid the aircraft of excess fuel by either continuing to fly or by releasing it from the aircraft while in-flight. The Air Force recently

increased the safe landing weight of a KC-135 (when runway length and landing conditions permit) thus allowing it to save fuel. However, changing the landing weight is only an available options for some aircraft. The C-5, for example, one of the heavier fuel users in the Air Force fleet, has the same take off and landing weight negating the need to get rid of excess fuel weight.

### **More Direct Flights**

Using the most direct routes between points can also reduce fuel consumption. However, under certain conditions, such when a foreign government has imposed over-flight restrictions on military aircraft, DOD may have to take circuitous paths. DOD is assessing flight paths to determine where it may be able to use more direct routes. The service has claimed that by doing so it saved \$46 million in Fiscal Year 2006.<sup>40</sup>

### **Relocate Aircraft**

Aircraft stationed close to the front lines need less fuel to reach the battlefield than those stationed at a distance. With fuel savings as a consideration, the Air Force repositioned B-1s from Diego Garcia to Al Udeid Air Base in Saudi Arabia. Assuming an approximate savings in flying miles of 2400 nautical miles, a cruising rate of about 450 nautical miles per hour, the move saves over 40,000 gallons of fuel per sortie.<sup>41</sup>

### **Decrease Aircraft Rotations**

Rotating aircraft between the United States and locations overseas takes a great deal of fuel—approximately 150,000-450,000 gallons per aircraft per rotation.<sup>42</sup> The Air Force re-assessed the number of time aircraft needed to rotate and concluded that fewer rotations would still enable it to adequately support combat operations.

## **Increase Simulator Use**

Many gallons of fuel are consumed training new pilots and maintaining the proficiency of experienced ones. Although simulators have been used to train aviators for many years, cockpit training has always been preferred. The DOD Fiscal Year 2007 budget request included funding to study the extent to which flight simulators can and should substitute for training in the actual aircraft. The department estimates that increasing simulator use could save \$1 billion a year.<sup>43</sup>

However, language contained in the FY 2007 Defense Authorization Bill may limit DOD's ability to aggressively pursue increased use of simulators. A September 2006 GAO study found that DOD use of its simulators fell short of what it paid for under service contracts.<sup>44</sup> Congress subsequently passed legislation prohibiting DOD from entering into service contracts for military flight simulators, which will require DOD to acquire and operate simulators in-house.<sup>45</sup> DOD contends that contractors' ability to maintain and quickly update simulators results in better training and cautions that department-run simulators may not be as effective.

## **Winglets**

Winglets, relatively small vertical extensions attached to the end of an aircraft's wingtips, reduce drag and can increase an aircraft's fuel efficiency.<sup>46</sup> The Air Force is sponsoring an ongoing study to assess the feasibility of applying winglets to large aircraft: refuelers, airlift, and intelligence, surveillance, and reconnaissance. Specifically, the study will determine the price of fuel at which applying winglets becomes cost-effective, their impact on maintenance and flight operations and a possible investment strategy.<sup>47</sup>



**Figure 1 KC-135 Winglet Flight Tests at Dryden Flight Research Center<sup>48</sup>**

### **Autonomous Refueling**

Much of the cost of air-to-air refueling is in its practice. Last fall, the DARPA successfully demonstrated unmanned refueling capabilities.<sup>49</sup> If DOD were to transition to such a refueling method, there could be great potential savings in the fuel and flying hours currently allocated for air-to-air refueling training. The acquisition of a new tanker would be an opportune time to field such a new capability.

### **Other**

Other strategies may further reduce aviation fuel use. One, borrowed from the commercial aviation industry, would be to remove extraneous weight such as unnecessary or redundant gear and provisions. Another currently unavailable in Air Force aircraft, is to track actual fuel use rate. Lack of a tracking mechanism makes it difficult to gauge how well fuel-saving strategies are working and makes users less aware of how well they are meeting reduction goals. In an attempt to instill awareness in its aviation community, Air Force leadership in fall 2006, communicated to its flying units the importance of adopting a fuel-saving culture and the service's goal of reducing aviation fuel consumption by 10% over the next five years. Although

a worthy effort, the extent to which individual operators will make a difference in DOD fuel consumption will be difficult to measure.

## Notes

<sup>1</sup> Elizabeth A. Bostic, Communications-Electronics Research Development and Engineering Center (CERDEC) Fuel Cell Team Leader, (remarks made at 2<sup>nd</sup> Annual Military Energy Alternatives, Arlington, VA, 21 February 2007).

<sup>2</sup> For further information on the Fischer-Tropsch process, see CRS RL32666, *The Gas to Liquids Industry and Natural Gas Markets*, by Robert Pirog.

<sup>3</sup> For further information on oil shale see CRS RL33359, *Oil Shale: History, Incentives, and Policy*, by Anthony Andrews.

<sup>4</sup> According to Mr. Mark Maddox, Principal Deputy Assistant Secretary for Fossil Energy, Department of Energy, an early 1980s study estimated that the United States contained approximately 1.8 trillion barrels worth of oil shale, approximately 300 billion of which is readily accessible. The oil shale is primarily concentrated in Utah, Colorado, and Wyoming. In Alberta, Canada, oil is produced from oil sands at a rate of over one million barrels per day, a rate that is expected to exceed two million barrels per day by 2013. Senate, *Oil Resource Development: Hearing before the Committee on Energy and Natural Resources*, 109 Cong., 1<sup>st</sup> sess., 2005, 9-10.

<sup>5</sup> Harrison presentation.

<sup>6</sup> Energy Information Administration, Coal Industry Annual 1995 (DOE/EIA-0584) (Washington D.C.: U.S. Department of Energy, 1995)

<sup>7</sup> JP-8 is the standard aviation fuel used in fixed-wing aircraft flown by the Air Force and in some Army ground vehicles. JP-5, which has a higher flash point than JP-8, was designed for use aboard aircraft carriers where the risk of fire is high. DOD is also planning on exploring the feasibility of using a synthetic fuel mixture that would meet the specifications of JP-5.

<sup>8</sup> Carbon sequestration is the practice of capturing carbon emissions at their source, before they are released into the atmosphere, then transporting them to a long-term storage location such as a geological reservoir or the deep ocean. For further information on carbon sequestration, see CRS RL33801, *Direct Carbon Sequestration: Capturing and Storing CO<sub>2</sub>*, by Peter Folger.

<sup>9</sup> In their draft environmental impact statement for a proposed CTL project in Pennsylvania, DOE stated that large-scale carbon sequestration may become “technically practicable within the next 15 years.” *Defense Environment Alert*, Vol 15, No. 2, January 23, 2007.

<sup>10</sup> “Air Force Seeks Commercial Airlines’ Support in Push for Synfuels.” *Inside the Air Force*, March 23, 2007.

<sup>11</sup> Senate, *The Future of Energy: Hearing before the Committee on Finance*, 110<sup>th</sup> Cong., 1<sup>st</sup> sess., 2007, 5.

<sup>12</sup> See, for example, Margaret Kriz, “Liquid Coal,” *The National Journal*, 6 January 2007.

<sup>13</sup> “Pentagon May Be Taking More Cautious Approach To Alternative Fuels,” *EnergyWashington Week*, 15 November 2006.

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<sup>14</sup> Jeff Tollefson, "Keystone State Lawmakers Upset Over Plan to Eliminate Coal Fuel Project." *CQ Today*, February 9, 2007.

<sup>15</sup> "DOD Forges Ahead With Synthetic Jet Fuel Plans." *Jet Fuel Intelligence*, December 4, 2006.

<sup>16</sup> Several media outlets have reported Air Force estimates of five processing plants, each producing 50,000 gallons a day, to meet their needs. See for example David Pugliese, "Lean, mean, and going green: The largest buyer of fossil fuel in the world, the Pentagon is racing to kick its habit, and the Canadian military is paying attention," *Ottawa Citizen*, 24 February 2007.

<sup>17</sup> Government Accountability Office, *CRUDE OIL: Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production*, GAO-07-283 (Washington, D.C., Government Accountability Office, February 2007), 60.

<sup>18</sup> Coal-To-Liquids Coalition, <http://www.futurecoalfuels.org/economy.asp>.

<sup>19</sup> Edward Cameron, Sasol Synfuels International (Pty) Ltd, "Synthetic Fuels—the Sasol Experience," (presented at 2<sup>nd</sup> Annual Military Energy Alternatives Conference, Arlington, VA, 21 February 2007).

<sup>20</sup> GAO Report, 60.

<sup>21</sup> 10 U.S.C. *Armed Forces*, Section 2306b, Multiyear contracts: acquisition of property.

<sup>22</sup> For further information on biofuels see CRS RL33564 Alternative Fuels and Advanced Technology Vehicles: Issues in Congress by Brent D. Yacobucci.

<sup>23</sup> Biodiesel is a synthetic fuel made from vegetable oils or animal fats. B20, the commonly used mix of 20% biodiesel and 80% petroleum-based diesel fuel—works in any diesel engine with few or no modifications necessary. DOD began using biodiesel in 2000 and is now the nation's top purchaser of B20, buying over 15 million gallons annually. All military departments use B20 in a variety of non-tactical vehicles. Because biodiesel is so easily integrated into the existing fuel supply infrastructure, it is more readily available across DOD than E85. For example, the Air Force has 58 bases that dispense B20 compared to 16 that can dispense E85. For more information see the National Biodiesel Board website at <http://www.biodiesel.org>. and "Biodiesel Fuel Tutorial" (online presentation, Defense Energy Support Center) available at <http://www.desc.dla.mil/dcm/Files/BiodieselTutorial.ppt>.

<sup>24</sup> See Synopsis A—BAA06-43-Biofuels on Federal Business Opportunities website at <http://www.fbo.gov/spg/ODA/DARPA/CMO/BAA06%2D43/SynopsisP.html>. Posted 6 July 2006.

<sup>25</sup> For further information on hydrogen and fuel cells, see CRS RL32196, *A Hydrogen Economy and Fuel Cells: An Overview* by Brent D. Yacobucci and Aimee E. Curtright.

<sup>26</sup> The amount of emissions produced as a result of using hydrogen fuel cells varies depending on the source of the hydrogen fuel. Hydrogen does not occur naturally by itself and must be extracted from other sources such as water or coal. If hydrogen fuel is obtained by burning a carbon rich resource such as coal, overall emissions increase.

<sup>27</sup> Stuart Funk et al, *Potential Use of Hydrogen as a Defense Logistics Fuel*, (McClean, VA: LMI Government Consulting, November 2004), 1-8.

<sup>28</sup> Gregg K. Kakesako, "Hydrogen fuel gains ground at Hickam." *Star Bulletin*, Vol 11, Issue 315, 12 November 2006.

<sup>29</sup> Ken Thomas, "Army to test hydrogen fuel cell vehicle." *Associated Press*, 22 September 2006.

<sup>30</sup> According to the Energy Information Administration, the average cost of a kilowatt hour of electricity in the United States in 2006 was 8.8 cents.

## Notes

<sup>31</sup>Kathi Epping, U.S. Department of Energy Hydrogen Program, Fuel Cell Sub Program, “Understanding the Role of Fuel Cells in Battlefield Operations” (presented at the 2<sup>nd</sup> Annual Military Energy Alternative Conference, Arlington, VA, 21 February 2007).

<sup>32</sup> LMI Report, iii.

<sup>33</sup> Ibid, 4-22.

<sup>34</sup> There are many causes for the increased energy demand including the need for climate control and the increased use of personal electronic devices by today’s service members.

<sup>35</sup> Dr. Rosemary Szostak, LMI Government Consulting, “Reducing Fuel Requirements with Alternative Technologies” (presented at 2<sup>nd</sup> Annual Military Energy Alternative Conference, Arlington, VA, 20 February 2007).

<sup>36</sup> Ibid.

<sup>37</sup> Ibid.

<sup>38</sup> “Garbage Gas: Polytechnic University Researcher Develops Bioplastic as a Disposable source of Biodiesel.” *PR Newswire US*, 21 March 2007.

<sup>39</sup> See <http://www.darpa.mil/dso/thrust/matdev/titanium.htm>.

<sup>40</sup> Lt Col Jonathan Owens (HQ USAF Air Force A3OT), interview by the author, 17 January 2007.

<sup>41</sup> Assumes a B-1 fuel burn rate of about 3874 gallons per flight hour.

<sup>42</sup> Lt Col Jonathan Owens, 17 January 2007.

<sup>43</sup> Department of Defense, “Energy Security Task Force, Overview of Findings” (slides from Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, 15 March 2007).

<sup>44</sup> Government Accountability Office, GAO-06-830, *Contract Management, Service Contract Approach to Aircraft Simulator Training Has Room For Improvement* (Washington D.C.: Government Accountability Office, September 2006), 3.

<sup>45</sup> P.L.109-364 (Section 832.) *Limitation on contracts for the Acquisition of Certain Services*.

1. (a) Limitation - Except as provided in subsection (b), the Secretary of Defense may not enter into a service contract to acquire a military flight simulator.

<sup>46</sup> Joseph R. Chambers, *Concept to Reality: Contributions of the NASA Langley Research Center to U.S. Civil Aircraft of the 1990s* (Washington D.C.: NASA, 2003), “Winglets”, <http://oea.larc.nasa.gov/PAIS/Concept2Reality/winglets.html>.

<sup>47</sup> The National Academies, “Current Projects: Assessment of Aircraft Winglets for large Aircraft Fuel Efficiency,” The National Academies, <http://www.nationalacademies.org/cp/projectview.aspx?key=48728.html> (accessed 13 April 2007).

<sup>48</sup> Chambers, “Winglets.”

<sup>49</sup> “DARPA Performs World’s First Hands-Off Autonomous Refueling Engagement.” *Scientific Frontline*, 7 September 2006.

## **Chapter 5**

### **Possible Impediments**

DOD, particularly the Department of the Air Force, has engaged in a number of positive steps to reduce the department's reliance on fossil fuels. However, the ultimate success of its loosely articulated strategy depends on whether it can overcome a number of shortfalls that currently beset it.

#### **DOD Leadership**

There does not appear to be a clear focal point to lead a DOD energy strategy. That there is a lack of leadership is recognized by many in the department and by others in the federal government.<sup>1</sup> This may adversely impact its ability to complete long-term projects that are underway and to fund or implement new ones.

Many offices within DOD have responsibility for individual energy related initiatives but the growing number and complexity of activities seem to have grown beyond the current organizational structure. The USD (AT&L) has been directed to ensure the implementation of President's Bush 2007 Executive Order and to "continue efforts of the Energy Security Task Force by implementing the findings and monitoring implementation."<sup>2</sup> However, there does not appear to be an individual within that office appointed to oversee a comprehensive department-wide energy strategy—to prioritize, coordinate, and advocate for the various ongoing projects.

There are a number of other DOD offices that play a role to varying degrees. The Office of the Deputy Under Secretary of Defense for Installations & Environment (DUSD (I&E)) has traditionally had oversight of energy issues related to utilities and facilities, but does not have any oversight of fuel savings initiatives in the operational community. The office of DDR&E oversees research and engineering efforts for the department and its director, the Honorable John J. Young, Jr., frequently speaks for DOD's on its fuel reduction efforts. DARPA sponsors active research that turns new discoveries into useful military applications but does not develop policy for the department. And although these offices all fall under USD (AT&L), other agencies that do not, including the military services, have ongoing projects that must also compete for a share of the DOD budget.

## **External Expectations**

In addition to the issue of leadership on energy within the department, there is also the issue of the degree to which DOD is willing to take on a leadership role for the nation. There are those outside the department that seem to view DOD as a potential leader in the nation's effort to develop alternative forms of energy, particularly synthetic aviation fuel. Although DOD's fuel purchasing power is relatively small compared to the purchasing power of the commercial aviation industry,<sup>3</sup> its tradition of being technologically forward-thinking is frequently cited as a basis for expecting leadership in this energy arena as well.<sup>4</sup>

DOD seems to eschew attempts to impose upon it a role beyond facilitator—a catalyst for the development of new technologies; a test-bed and potential market. When questioned by the House Armed Subcommittees on Terrorism, Unconventional Threats, and Capabilities and Readiness regarding DOD's role in developing new technologies for alternative fuels, DOD witnesses consistently responded in language that drew clear boundaries around DOD's role:<sup>5</sup>

**Mr. John Young, DDR&E:** “So, across the board, I think the department is a partner with other agencies in the government and the commercial industry, which is helping to drive this space, and push the technology forward both on revolutionary spaces and then in areas where we see – or evolutionary spaces and then places where we see chances at a revolution...”

**Mr. Philip Grone, DUSD (I&E):** “So I do think there’s a synergy between activities of the department, activities of the broader federal family and industry, both in research and development and the actual application of the technologies, the vehicles, where we can have an effect on understanding and ultimately of markets in terms of demonstrating the viability of certain technologies.”

**Mr. Michael Aimone, Deputy Chief of Staff, Air Force Installations, Logistics, and Mission Support:** “...And then my counterpart in the Navy and I went to Wright Patterson and we compared our programs, invited the Army Department of Energy to come in place. And what we found out there was a phenomenal program that has been in being for years, but just needed a little bit of executive leadership to bring it out of the weeds. That, sir, is part of what the Air Force can do and I think is doing. We have the ability to certify fuel for aviation airworthiness.”

**Mr. Richard Connelly, Director, DESC:** “...I think it’s the role of the services and the department, DOD, to give us [DESC] the go ahead and the operational supply chain manager, to go ahead and move forward in these markets. You did mention, Mr. Chairman, earlier the percentage of domestic consumption. Internationally, that translates to something less than one-half of one percent of total fuel consumed. So while we are probably the biggest single purchaser of fuel in the world and certainly a voice to be heard in the marketplace, we’re not going to move the market, but we can try to exhibit some leadership.”

Within DOD, the Air Force is viewed as being on the front-line in the development of alternative aviation fuel. The service has received much attention for its initiative to test and certify a synthetic fuel blend in its B-52 but, even as it continues to announce its intention to acquire 50% of its domestically purchased fuel as a synthetic blend by 2016, the service remains steadfast that it needs the support of the commercial aviation industry.<sup>6</sup>

To what extent the commercial aviation industry is prepared to expand its own role in developing synthetic aviation fuel is unclear. In her remarks to the 2007 Air Force Energy Forum, Ms. Marion Blakey, Administrator of the Federal Aviation Administration, stated, “It’s clear that the military’s energy security mission is something we’re all going to have to be a part

of.”<sup>7</sup> and later, acknowledging DOD’s 2016 goal added, “And I want Secretary Wynne and all of you to know that the commercial side will be right there with you.”<sup>8</sup>

## Funding

The department’s view of itself as an important but not the most important participant in the nation’s quest for alternative energy seems to be consistent with its funding strategy. According to DDR&E, \$1.8 billion of DOD’s FY 2007- FY 2011 budget is intended for energy related projects.<sup>9</sup> In contrast, the FY 2008 Defense Appropriations Act provided over \$75.5 billion for Research, Development, Test and Evaluation for the entire department.

The Air Force, the largest user of aviation fuel, also seems reluctant to use scarce operational funds for energy-efficiency improvements at this time. Government studies indicate that the most cost-effective way to reduce reliance on fossil fuel—absent leaps in technology that make synthetic fuel abundant and affordable—is to increase the energy-efficiency of current weapon systems. Engine upgrades are specifically highlighted as a readily available and relatively affordable way to do that.

However, amid debates between Congress and the Air Force over which and how many aircraft the service should retire, the Air Force seems reluctant to spend money upgrading aging aircraft. Upgrading the B-52H engine was one of the possible solutions noted in the Defense Science Task Force 2001 study. The DSB submitted that engine upgrades would not only reduce fuel usage on the B-52H but that studies suggested they would also reduce tanker force structure requirements.<sup>10</sup> Nonetheless, in March 2007, *Defense Daily* reported that the Air Force declined a proposal by engine manufacturer Pratt&Whitney to upgrade the B-52H bomber’s TF-33 engines, some of the oldest in the service’s inventory. (According to *Defense Daily*, B-52H is expected to remain in service until 2040.<sup>11</sup>)

## Notes

<sup>1</sup> At the 2<sup>nd</sup> Annual Defense Energy Alternatives Conference in February 2007, a representative from the Defense Energy Support Center stated that the lack of a central DOD energy office that could interact with DESC, Department of Energy, and other agencies was a “huge problem in DOD.” In November 2006, a DOD member stated during an interview with the author that there was no single focal point to lead the department’s efforts in energy. In December 2006, a DOD member involved with the Energy Security Task Force related that although DDR&E had the acting role of coordinator for the task force, no office or individual within DOD had been designated as wholly responsible for coordinating the various energy-related activities within the department.

<sup>2</sup> The Honorable Gordon England, Deputy Secretary of Defense, to Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, Under Secretary of Defense for Acquisition, Technology, and Logistics, 16 February 2007. The memo states in part that USD (AT&L) will “develop and implement necessary policies and guidance to support implementation [of President Bush’s Executive Order 13423.]”

<sup>3</sup> The Honorable Michael Wynne, Secretary of the Air Force (address, Air Force Energy Forum, Arlington, VA, 8 March 2007). Mr. Wynne stated that the buying power of the commercial airlines “constitutes approximately 85% of the market.”

<sup>4</sup> See for example James Bernstein, “A powerful mission; At Congressman’s behest, LI defense contractors agree to seek alternative fuels,” *Newsday*, October 19, 2006.

<sup>5</sup> House, Subcommittees on Terrorism, Unconventional Threats and Capabilities; and Readiness of the House Armed Service Committee, *Alternative Energy and Energy Efficiency Programs at the Department of Defense*, 109<sup>th</sup> Cong., 2<sup>nd</sup> sess., 2006, Congressional Quarterly Transcription, 13-15.

<sup>6</sup> Wynne address to the Air Force Energy Forum, 8 March 2007.

<sup>7</sup> “‘Civil Aviation Gets Green Light,’ by Marion C. Blakey.” *States News Service*, 8 March 2007.

<sup>8</sup> *Ibid.*

<sup>9</sup> The Honorable John J. Young, Jr., DDR&E, and Mr. Philip W. Grone, DUSD (I&E), “Joint Statement before the House Subcommittees on Terrorism, Unconventional Threats and Capabilities; and Readiness of the House Armed Service Committee,” 26 September 2006, 8.

<sup>10</sup> DSB Report, ES-5.

<sup>11</sup> Michael Sirak, “Pratt & Whitney Offers air Force Upgrades To TF-33 Engines On B-52H Bomber,” *Defense Daily*, 29 Mar 2007.

## **Chapter 6**

### **Analysis and Conclusions**

DOD needs designated leadership—ideally at the Deputy Under Secretary level—to ensure measured and consistent progress toward its goal to reduce its reliance on fossil fuels. Without a dedicated advocate, energy-related activities with long-term pay-off will not compete favorably in today's severe budget environment. That there is “no silver bullet” for the department's and the nation's energy woes is frequently repeated—no single technology currently offers the perfect blend of energy density, affordability, and environmental benefits. Consequently, there are myriad interests and promising technologies that must be balanced with national security needs, DOD's budget, and the welfare of the environment. DOD must commit the leadership and resources to do this.

DOD's reluctance to do so may reflect its self-image as an important but peripheral participant in the nation's quest for alternative energy. It may be that since DOD does not plan on assuming a national level leadership role in energy, it feels no compulsion to establish an organizational construct that will allow it to develop its own robust energy strategy. However, without one, DOD's current “strategy” is likely to be short-lived.

It may also be that DOD's lack of serious movement toward a comprehensive and well-led energy policy is not a conscious plan but simply the reflection of a government that seems disinclined to move out smartly on a serious energy strategy. In a February 2007 report, GAO

found that “there is no federal strategy for reducing uncertainty about the peak’s<sup>1</sup> timing or mitigating its consequences.”<sup>2</sup> This latest wave of national urgency is still relatively young having been set off by Hurricane Katrina in August 2005 and one could argue that there has not yet been sufficient momentum to form a coherent strategy. But one can sense in the copious writings, testimonies, and studies since then that the disparate projects the urgency has spawned at every level of government are now crying out for organization, prioritization, and direction.

Evidence abounds to suggest the GAO is correct in their assessment. In its response to the GAO report, the Department of Energy agreed that “GAO’s recommendation that the Federal Government establish a coordinated strategy to deal with a potential peak in oil production is a reasonable one.” but did not offer to lead the effort. FAA also appears unwilling to fill the leadership void as evidenced by Ms. Blakey’s statement at the Air Force Energy Forum, “And I want Secretary Wynne and all of you to know that the commercial side will be right there with you.”<sup>3</sup>—not leading the way, but right there next to DOD.

Differing opinions about the size of the problem complicates the public dialogue about how prominent a role DOD should have in the national effort. In their September 2006 report, JASON asserted that with current usage rates, DOD would likely have access to sufficient amounts of domestic oil for at least the next 25 years. But those who strongly advocate pursuing CTL technology present a shortage of domestically produced fuel as a looming challenge.

Representative Nick Rahall (D-WV), who is sponsoring a bill that promotes CTL technology, referred to other technological solutions in the following terms: “They certainly do not solve our military’s energy challenges. From a practical standpoint, it is abundantly evident that the answer lies in coal.”<sup>4</sup> Indeed, DOD and others are pursuing several other technologies

including synthetic aviation biofuel and hydrogen fuel cells, which, within 25 years, may well be mature enough to power the DOD of the future.

In testimony before the Senate Armed Services Committee, Air Force Secretary Michael Wynne seemed to choose words intended to convey the Air Force and DOD's view on the nature of the "crisis" and the department's place in it:

I would tell you that there are some that really believe that as an Air Force, we would have first priority call over the civilians if it was truly a need for our Air Force to go secure fuel. I just don't think I ever want to be put in that position, and I actually want to be the source of technology so that my other airline colleagues can look elsewhere and maybe not get us into that hedge. It's one of those hedge bets that I think somebody in government has to make, even though we hope it never comes true.<sup>5</sup>

In other words, DOD will have first chance at the last of the fuel reserves so, airline industry, it is time to get on-board and start helping us look for alternative fuel sources because you will need them before we do...

But by adding DOD specific language to bills that promote F-T CTL technology and by suggesting that DOD's energy challenges are more daunting than they may be, many in Congress and industry are pushing DOD and the Air Force onto center stage. In the words of one Senate aide, "The CTL crowd has hitched a wagon to Defense Department's efforts to move to synthetic fuels."<sup>6</sup> Whether DOD wants to accept the role or not, the department may be forced to wear it—for how long or to what degree is uncertain. Currently, without a comprehensive strategy and dedicated leadership, the department is ill-equipped to do that.

For another reason, DOD must put a comprehensive plan and organization in place to carry out a corporate strategy of its own. Whatever form of leadership DOD ends up with on the national stage, its unique combat requirements allow the department to demonstrate to the nation that advanced energy technologies are worth pursuing regardless of the price of oil. Versatile renewable fuels that shorten supply chains and reduce casualties, hydrogen fuel cells that provide

stealth and longer duration, composite materials that provide more strength with less weight, and aviation fuel that burns cleaner—their value does not depend on the price of oil.

Achieving 100% fuel independence may not be a realistic goal for DOD for the foreseeable future. But a dedicated DOD leader, focused on a roadmap for the department that is part of a comprehensive plan for the United States, can achieve reasonable goals that are good for DOD, good for the warfighter, and good for the nation.

## Notes

<sup>1</sup> “Peak Oil”—the point at which global oil production peaks and then steadily declines. In its report, GAO stated most studies estimate that peak oil will occur sometime between now and 2040.

<sup>2</sup> Government Accountability Office, *CRUDE OIL: Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production*, (Washington, D.C.: Government Accountability Office, February 2007), Executive Summary.

<sup>3</sup> “‘Civil Aviation Gets Green Light,’ by Marion C. Blakey.” *States News Service*, march 8 2007.

<sup>4</sup> “Senator Eyes Defense Bill As Vehicle For Coal-To-Liquid Fuel Bill.” *EnergyWashington Week*, March 28, 2007.

<sup>5</sup> Congressional Quarterly transcript of Senate Armed Services Committee Hearing on the Fiscal 2008 Air Force Budget Request, March 20, 2007.

<sup>6</sup> Manimoli Dinesh, “Biofuels Versus Alternative Fuels Battle Looms,” *Oil Daily*, 5 April 2007.

## **Appendix A**

### **Legislative Activity**

#### **FY 2007 Defense Authorization Act (H.R. 5122/P.L. 109-364)**

**Section 354 of the Senate-passed version of the FY2007 defense authorization bill (S. 2766) stated:**

SEC. 354. REPORT ON ACTIONS TO REDUCE DEPARTMENT OF DEFENSE CONSUMPTION OF PETROLEUM-BASED FUEL.

(a) Report Required- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the actions taken, and to be taken, by the Department of Defense to reduce the consumption by the Department of petroleum-based fuel.

(b) Elements- The report shall include the status of implementation by the Department of the requirements of the following:

(1) The Energy Policy Act of 2005 (Public Law 109-58).

(2) The Energy Policy Act of 1992. (Public Law 102-486)

(3) Executive Order 13123.

(4) Executive Order 13149.

(5) Any other law, regulation, or directive relating to the consumption by the Department of petroleum-based fuel.

**Section 375 of the Senate-passed version of S.2766 stated:**

SEC. 375. ENERGY EFFICIENCY IN WEAPONS PLATFORMS.

(a) Policy- It shall be the policy of the Department of Defense to improve the fuel efficiency of weapons platforms, consistent with mission requirements, in order to--

- (1) enhance platform performance;
- (2) reduce the size of the fuel logistics systems;
- (3) reduce the burden high fuel consumption places on agility;
- (4) reduce operating costs; and
- (5) dampen the financial impact of volatile oil prices.

(b) Report Required-

(1) IN GENERAL- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report on the progress of the Department of Defense in implementing the policy established by subsection (a).

(2) ELEMENTS- The report shall include the following:

(A) An assessment of the feasibility of designating a senior Department of Defense official to be responsible for implementing the policy established by subsection (a).

(B) A summary of the recommendations made as of the time of the report by--

(i) the Energy Security Integrated Product Team established by the Secretary of Defense in April 2006;

(ii) the Defense Science Board Task Force on Department of Defense Energy Strategy established by the Under Secretary of Defense for Acquisition, Technology and Logistics on May 2, 2006; and

(iii) the January 2001 Defense Science Board Task Force report on Improving Fuel Efficiency of Weapons Platforms.

(C) For each recommendation summarized under subparagraph (B)--

(i) the steps that the Department has taken to implement such recommendation;

(ii) any additional steps the Department plans to take to implement such recommendation; and

(iii) for any recommendation that the Department does not plan to implement, the reasons for the decision not to implement such recommendation.

(D) An assessment of the extent to which the research, development, acquisition, and logistics guidance and directives of the Department for weapons platforms are appropriately designed to address the policy established by subsection (a).

(E) An assessment of the extent to which such guidance and directives are being carried out in the research, development, acquisition, and logistics programs of the Department.

(F) A description of any additional actions that, in the view of the Secretary, may be needed to implement the policy established by subsection (a).

### **Conference Report**

**Section 358 of H.R. 5122/L.L. 109-364 (conference report H.Rept. 109-702 of 29 September 2006) stated:**

**SEC. 358. UTILIZATION OF FUEL CELLS AS BACK-UP POWER SYSTEMS IN DEPARTMENT OF DEFENSE OPERATIONS.**

The Secretary of Defense shall consider the utilization of fuel cells as replacements for current back-up power systems in a variety of Department of Defense operations and activities, including in telecommunications networks, perimeter security, individual equipment items, and remote facilities, in order to increase the operational longevity of back-up power systems and stand-by power systems in such operations and activities.

**Section 360 stated:**

**SEC. 360. ENERGY EFFICIENCY IN WEAPONS PLATFORMS.**

(a) Policy- It shall be the policy of the Department of Defense to improve the fuel efficiency of weapons platforms, consistent with mission requirements, in order to--

- (1) enhance platform performance;
- (2) reduce the size of the fuel logistics systems;
- (3) reduce the burden high fuel consumption places on agility;
- (4) reduce operating costs; and
- (5) dampen the financial impact of volatile oil prices.

(b) Report Required-

(1) IN GENERAL- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report on the progress of the Department of Defense in implementing the policy established by subsection (a).

(2) ELEMENTS- The report shall include the following:

(A) An assessment of the feasibility of designating a senior Department of Defense official to be responsible for implementing the policy established by subsection (a).

(B) A summary of the recommendations made as of the time of the report by--

(i) the Energy Security Integrated Product Team established by the Secretary of Defense in April 2006;

(ii) the Defense Science Board Task Force on Department of Defense Energy Strategy established by the Under Secretary of Defense for Acquisition, Technology and Logistics on May 2, 2006; and

(iii) the January 2001 Defense Science Board Task Force report on Improving Fuel Efficiency of Weapons Platforms.

(C) For each recommendation summarized under subparagraph (B)--

(i) the steps that the Department has taken to implement such recommendation;

(ii) any additional steps the Department plans to take to implement such recommendation; and

(iii) for any recommendation that the Department does not plan to implement, the reasons for the decision not to implement such recommendation.

(D) An assessment of the extent to which the research, development, acquisition, and logistics guidance and directives of the Department for weapons platforms are appropriately designed to address the policy established by subsection (a).

(E) An assessment of the extent to which such guidance and directives are being carried out in the research, development, acquisition, and logistics programs of the Department.

(F) A description of any additional actions that, in the view of the Secretary, may be needed to implement the policy established by subsection (a).

**The House Committee on Armed Services, in its report (R.Rept 109-452 of 5 May 2006) on H.R.5122 stated:**

**Winglets for in-service aircraft**

The committee commends the Air Force in its efforts to increase aircraft fuel efficiency and decrease fuel consumption. The committee notes that initiatives such as re-engining aircraft, modifying in-flight profiles, and revising aircraft ground operations contribute to decreased fuel consumption and increased life-cycle savings.

The committee is aware that winglet technology exists for aircraft to increase fuel efficiency, improve take-off performance, increase cruise altitudes, and increase payload and range capability. The committee notes that winglets are currently used on commercial aircraft and result in a five to seven percent increase in fuel efficiency. On September 16, 1981, the National Aeronautics and Space Administration released the KC-135 Winglet Program Review on the incorporation of winglets for KC-135 aerial refueling aircraft. However, the Air Force concluded that the cost of adding winglets to the KC-135 did not provide sufficient payback in fuel savings or increased range to justify modification. Although the Air Force did conclude that modifying aircraft with winglets could increase fuel efficiency, the Air Force determined that

re-engining the KC-135 aircraft produced a greater return on investment. The committee believes that incorporating winglets on military aircraft could increase fuel efficiency on certain platforms and that the Air Force should reexamine incorporating this technology onto its platforms.

Therefore, the committee directs the Secretary of the Air Force to provide a report to the congressional defense committees by March 1, 2007, examining the feasibility of modifying Air Force aircraft with winglets. The report shall include a cost comparison analysis of the cost of winglet modification compared to the return on investment realized over time for each airlift, aerial refueling, and intelligence, surveillance, and reconnaissance aircraft in the Air Force inventory; the market price of aviation fuel at which incorporating winglets would be beneficial for each Air Force platform; all positive and negative impacts to aircraft maintenance and flight operations; and investment strategies the Air Force could implement with commercial partners to minimize Air Force capital investment and maximize investment return.

**FY2007 Defense Appropriations Act (H.R. 5631/P.L. 109-289)**

**The Senate Appropriations Committee, in its report (S.Rept. 109-292 of 25 July 2006) on H.R.5631, stated:**

*Alternative Diesel Fuel.*--The Committee notes the recent developments relating to the conversion of coal to liquid fuels. Demonstration projects in the United States have produced high-quality, ultra clean synthetic diesel fuels that provide improved efficiency and improved emissions compared to traditionally produced diesel fuel. The Committee encourages the Department of Defense to continue to explore the use of Fischer--Tropsch fuels as alternative sources for DOD's fuel requirements. Further, the Committee requests that the Under Secretary for Acquisition, Technology, and Logistics prepare a report for the congressional defense committees on the Defense Department's assessment, use, and plans to continue to explore the potential of synthetic fuels, to include fuels produced through the Fischer--Tropsch process.

**The House Appropriations Committee, in its report (H.Rept 109-504 of 16 June 2006) on H.R.5631 stated:**

#### **C-32 WINGLET MODIFICATION**

The Committee recommends \$5,198,000 for C-32 modifications, which is \$5,006,000 more than the amount provided in fiscal year 2006, and \$5,000,000 more than the request for fiscal year 2007. These funds shall be used to install Blended Winglets on the 4 C-32 aircraft operated by the United States Air Force to demonstrate potential fuel savings, and/or increased operating range. Not more than one year after the modification of the first C-32 aircraft, the Secretary of the Air Force shall submit a report to the congressional defense committees assessing the utility of the winglet and making a recommendation if the program should be expanded to other types of aircraft.

#### **Coal-to-Liquid Fuel Energy Act of 2007 (S.154)**

**Section 5** of Senate Bill S.154 of 4 January 2007 states:

#### **SEC. 5. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.**

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

**Section 6** states:

#### **SEC. 6. STRATEGIC PETROLEUM RESERVE.**

(a) Development, Operation, and Maintenance of Reserve- Section 159 of the Energy Policy and Conservation Act (42 U.S.C. 6239) is amended--

(1) by redesignating subsections (f), (g), (j), (k), and (l) as subsections (a), (b), (e), (f), and (g), respectively; and

(2) by inserting after subsection (b) (as redesignated by paragraph (1)) the following:

(c) Study of Maintaining Coal-to-Liquid Products in Reserve- Not later than 1 year after the date of enactment of the Coal-to-Liquid Fuel Energy Act of 2007, the Secretary and the Secretary of Defense shall--

(1) conduct a study of the feasibility and suitability of maintaining coal-to-liquid products in the Reserve; and

(2) submit to the Committee on Energy and Natural Resources and the Committee on Armed Services of the Senate and the Committee on Energy and Commerce and the Committee on Armed Services of the House of Representatives a report describing the results of the study.

(d) Construction of Storage Facilities- As soon as practicable after the date of enactment of the Coal-to-Liquid Fuel Energy Act of 2007, the Secretary may construct 1 or more storage facilities in the vicinity of pipeline infrastructure and at least 1 military base.'

(b) Petroleum Products for Storage in Reserve- Section 160 of the Energy Policy and Conservation Act (42 U.S.C. 6240) is amended--

(1) in subsection (a)--

(A) in paragraph (1), by inserting a semicolon at the end;

(B) in paragraph (2), by striking 'and' at the end;

(C) in paragraph (3), by striking the period at the end and inserting ';' and'; and

(D) by adding at the end the following:

'(4) coal-to-liquid products (as defined in section 2 of the Coal-to-Liquid Fuel Energy Act of 2007), as the Secretary determines to be appropriate, in a quantity not to exceed 20 percent of the total quantity of petroleum and petroleum products in the Reserve.'

(2) in subsection (b), by redesignating paragraphs (3) through (5) as paragraphs (2) through (4), respectively; and

(3) by redesignating subsections (f) and (h) as subsections (d) and (e), respectively.

(c) Conforming Amendments- Section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247) is amended--

(1) in subsection (b)--

(A) by redesignating paragraphs (2) and (3) as paragraphs (1) and (2), respectively; and

(B) in paragraph (2) (as redesignated by subparagraph (A)), by striking 'section 160(f)' and inserting 'section 160(e)'; and

(2) in subsection (d), in the matter preceding paragraph (1), by striking 'section 160(f)' and inserting 'section 160(e)'.

**Section 7** states:

SEC. 7. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

**Section 8** states:

SEC. 8. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended--

(1) in subsection (b)--

(A) by striking 'The Secretary' and inserting the following:

(1) IN GENERAL- The Secretary'; and

(B) by adding at the end the following:

(2) COAL-TO-LIQUID PRODUCTION FACILITIES-

(A) IN GENERAL- The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 2 of the Coal-to-Liquid Fuel Energy Act of 2007) on or near military installations.

(B) CONSIDERATIONS- In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.';

(2) in subsection (d)--

(A) by striking 'Subject to applicable provisions of law, any' and inserting 'Any'; and

(B) by striking '1 or more years' and inserting 'up to 25 years'; and

(3) by adding at the end the following:

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section..

**Section 9** states:

**SEC. 9. REPORT ON EMISSIONS OF FISCHER-TROPSCH PRODUCTS USED AS TRANSPORTATION FUELS.**

(a) In General- In cooperation with the Administrator of the Environmental Protection Agency, the Secretary of Defense, the Administrator of the Federal Aviation Administration, and the Secretary of Health and Human Services, the Secretary shall--

(1) carry out a research and demonstration program to evaluate the emissions of the use of Fischer-Tropsch fuel for transportation, including diesel and jet fuel;

(2) evaluate the effect of using Fischer-Tropsch transportation fuel on land and air engine exhaust emissions; and

(3) in accordance with subsection (e), submit to Congress a report on the effect on air quality and public health of using Fischer-Tropsch fuel in the transportation sector.

(b) Guidance and Technical Support- The Secretary shall issue any guidance or technical support documents necessary to facilitate the effective use of Fischer-Tropsch fuel and blends under this section.

(c) Facilities- For the purpose of evaluating the emissions of Fischer-Tropsch transportation fuels, the Secretary shall--

(1) support the use and capital modification of existing facilities and the construction of new facilities at the research centers designated in section 417 of the Energy Policy Act of 2005 (42 U.S.C. 15977); and

(2) engage those research centers in the evaluation and preparation of the report required under subsection (a)(3).

(d) Requirements- The program described in subsection (a)(1) shall consider--

(1) the use of neat (100 percent) Fischer-Tropsch fuel and blends of Fischer-Tropsch fuels with conventional crude oil-derived fuel for heavy-duty and light-duty diesel engines and the aviation sector; and

(2) the production costs associated with domestic production of those fuels and prices for consumers.

(e) Reports- The Secretary shall submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Energy and Commerce of the House of Representatives--

(1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and

(2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

### **Coal-to-Liquid Fuel Promotion Act of 2007 (S.155)**

**Section 104** of Senate Bill S.155 of 4 January 2007 states:

#### **SEC. 104. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.**

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

**Section 105** states:

#### **SEC. 105. STRATEGIC PETROLEUM RESERVE.**

(a) Development, Operation, and Maintenance of Reserve- Section 159 of the Energy Policy and Conservation Act (42 U.S.C. 6239) is amended--

(1) by redesignating subsections (f), (g), (j), (k), and (l) as subsections (a), (b), (e), (f), and (g), respectively; and

(2) by inserting after subsection (b) (as redesignated by paragraph (1)) the following:

(c) Study of Maintaining Coal-to-Liquid Products in Reserve- Not later than 1 year after the date of enactment of the Coal-to-Liquid Fuel Promotion Act of 2007, the Secretary and the Secretary of Defense shall--

(1) conduct a study of the feasibility and suitability of maintaining coal-to-liquid products in the Reserve; and

(2) submit to the Committee on Energy and Natural Resources and the Committee on Armed Services of the Senate and the Committee on Energy and Commerce and the Committee on Armed Services of the House of Representatives a report describing the results of the study.

(d) Construction of Storage Facilities- As soon as practicable after the date of enactment of the Coal-to-Liquid Fuel Promotion Act of 2007, the Secretary may construct 1 or more storage facilities in the vicinity of pipeline infrastructure and at least 1 military base.'

(b) Petroleum Products for Storage in Reserve- Section 160 of the Energy Policy and Conservation Act (42 U.S.C. 6240) is amended--

(1) in subsection (a)--

(A) in paragraph (1), by inserting a semicolon at the end;

(B) in paragraph (2), by striking 'and' at the end;

(C) in paragraph (3), by striking the period at the end and inserting ';' and'; and

(D) by adding at the end the following:

(4) coal-to-liquid products (as defined in section 101 of the Coal-to-Liquid Fuel Promotion Act of 2007), as the Secretary determines to be appropriate, in a quantity not to exceed 20 percent of the total quantity of petroleum and petroleum products in the Reserve.';

(2) in subsection (b), by redesignating paragraphs (3) through (5) as paragraphs (2) through (4), respectively; and

(3) by redesignating subsections (f) and (h) as subsections (d) and (e), respectively.

(c) Conforming Amendments- Section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247) is amended--

(1) in subsection (b)--

(A) by redesignating paragraphs (2) and (3) as paragraphs (1) and (2), respectively; and

(B) in paragraph (2) (as redesignated by subparagraph (A)), by striking 'section 160(f)' and inserting 'section 160(e)'; and

(2) in subsection (d), in the matter preceding paragraph (1), by striking 'section 160(f)' and inserting 'section 160(e)'.

**Section 106** states:

SEC. 106. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

**Section 107** states:

SEC. 107. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended--

(1) in subsection (b)--

(A) by striking 'The Secretary' and inserting the following:

(1) IN GENERAL- The Secretary'; and

(B) by adding at the end the following:

(2) COAL-TO-LIQUID PRODUCTION FACILITIES-

(A) IN GENERAL- The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 101 of the Coal-to-Liquid Fuel Promotion Act of 2007) on or near military installations.

(B) CONSIDERATIONS- In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.';

(2) in subsection (d)--

(A) by striking 'Subject to applicable provisions of law, any' and inserting 'Any'; and

(B) by striking '1 or more years' and inserting 'up to 25 years'; and

(3) by adding at the end the following:

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.'

**Section 108** states:

**SEC. 108. REPORT ON EMISSIONS OF FISCHER-TROPSCH PRODUCTS USED AS TRANSPORTATION FUELS.**

(a) In General- In cooperation with the Administrator of the Environmental Protection Agency, the Secretary of Defense, the Administrator of the Federal Aviation Administration, and the Secretary of Health and Human Services, the Secretary shall--

(1) carry out a research and demonstration program to evaluate the emissions of the use of Fischer-Tropsch fuel for transportation, including diesel and jet fuel;

(2) evaluate the effect of using Fischer-Tropsch transportation fuel on land and air engine exhaust emissions; and

(3) in accordance with subsection (e), submit to Congress a report on the effect on air quality and public health of using Fischer-Tropsch fuel in the transportation sector.

(b) Guidance and Technical Support- The Secretary shall issue any guidance or technical support documents necessary to facilitate the effective use of Fischer-Tropsch fuel and blends under this section.

(c) Facilities- For the purpose of evaluating the emissions of Fischer-Tropsch transportation fuels, the Secretary shall--

(1) support the use and capital modification of existing facilities and the construction of new facilities at the research centers designated in section 417 of the Energy Policy Act of 2005 (42 U.S.C. 15977); and

(2) engage those research centers in the evaluation and preparation of the report required under subsection (a)(3).

(d) Requirements- The program described in subsection (a)(1) shall consider--

(1) the use of neat (100 percent) Fischer-Tropsch fuel and blends of Fischer-Tropsch fuels with conventional crude oil-derived fuel for heavy-duty and light-duty diesel engines and the aviation sector; and

(2) the production costs associated with domestic production of those fuels and prices for consumers.

(e) Reports- The Secretary shall submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Energy and Commerce of the House of Representatives--

(1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and

(2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

### **Coal-to-Liquid Fuel Promotion Act of 2007 (H.R.370)**

**Section 104** of House Bill H.R.370 of 10 January 2007 states:

#### **SEC. 104. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.**

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

**Section 105** states:

#### **SEC. 105. STRATEGIC PETROLEUM RESERVE.**

(a) Development, Operation, and Maintenance of Reserve- Section 159 of the Energy Policy and Conservation Act (42 U.S.C. 6239) is amended--

(1) by redesignating subsections (f), (g), (j), (k), and (l) as subsections (a), (b), (e), (f), and (g), respectively; and

(2) by inserting after subsection (b) (as redesignated by paragraph (1)) the following:

(c) Study of Maintaining Coal-to-Liquid Products in Reserve- Not later than 1 year after the date of enactment of the Coal-to-Liquid Fuel Promotion Act of 2007, the Secretary and the Secretary of Defense shall--

(1) conduct a study of the feasibility and suitability of maintaining coal-to-liquid products in the Reserve; and

(2) submit to the Committee on Energy and Natural Resources and the Committee on Armed Services of the Senate and the Committee on Energy and Commerce and the Committee on Armed Services of the House of Representatives a report describing the results of the study.

(d) Construction of Storage Facilities- As soon as practicable after the date of enactment of the Coal-to-Liquid Fuel Promotion Act of 2007, the Secretary may construct 1 or more storage facilities in the vicinity of pipeline infrastructure and at least 1 military base.'

**Section 106** states:

SEC. 106. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

**Section 107** states:

SEC. 107. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended--

(1) in subsection (b)--

(A) by striking 'The Secretary' and inserting the following:

'(1) IN GENERAL- The Secretary'; and

(B) by adding at the end the following:

**'(2) COAL-TO-LIQUID PRODUCTION FACILITIES-**

**'(A) IN GENERAL-** The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 101 of the Coal-to-Liquid Fuel Promotion Act of 2007) on or near military installations.

**'(B) CONSIDERATIONS-** In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.';

(2) in subsection (d)--

(A) by striking 'Subject to applicable provisions of law, any' and inserting 'Any'; and

(B) by striking '1 or more years' and inserting 'up to 25 years'; and

(3) by adding at the end the following:

**'(f) Authorization of Appropriations-** There are authorized to be appropriated such sums as are necessary to carry out this section.'

**Section 108** states:

**SEC. 108. REPORT ON EMISSIONS OF FISCHER-TROPSCH PRODUCTS USED AS TRANSPORTATION FUELS.**

(a) **In General-** In cooperation with the Administrator of the Environmental Protection Agency, the Secretary of Defense, the Administrator of the Federal Aviation Administration, and the Secretary of Health and Human Services, the Secretary shall--

(1) carry out a research and demonstration program to evaluate the emissions of the use of Fischer-Tropsch fuel for transportation, including diesel and jet fuel;

(2) evaluate the effect of using Fischer-Tropsch transportation fuel on land and air engine exhaust emissions; and

(3) in accordance with subsection (e), submit to Congress a report on the effect on air quality and public health of using Fischer-Tropsch fuel in the transportation sector.

(b) **Guidance and Technical Support-** The Secretary shall issue any guidance or technical support documents necessary to facilitate the effective use of Fischer-Tropsch fuel and blends under this section.

(c) Facilities- For the purpose of evaluating the emissions of Fischer-Tropsch transportation fuels, the Secretary shall--

- (1) support the use and capital modification of existing facilities and the construction of new facilities at the research centers designated in section 417 of the Energy Policy Act of 2005 (42 U.S.C. 15977); and
- (2) engage those research centers in the evaluation and preparation of the report required under subsection (a)(3).

(d) Requirements- The program described in subsection (a)(1) shall consider--

- (1) the use of neat (100 percent) Fischer-Tropsch fuel and blends of Fischer-Tropsch fuels with conventional crude oil-derived fuel for heavy-duty and light-duty diesel engines and the aviation sector; and
- (2) the production costs associated with domestic production of those fuels and prices for consumers.

(e) Reports- The Secretary shall submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Energy and Commerce of the House of Representatives--

- (1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and
- (2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

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